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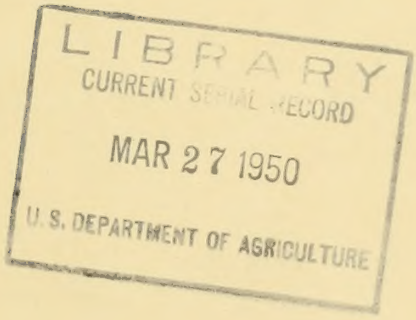
UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Economics

METHODS OF HARVESTING GRASS SILAGE IN NORTHEASTERN PENNSYLVANIA

(A Preliminary Report)



Washington, D.C.
February 1950

PREFACE

This report contains limited data on farmers' experiences and costs in harvesting grass silage. A few copies are made available at this time in mimeographed form, because of a scarcity of such information. No thorough study of the subject has been made but these preliminary findings can be helpful until such studies have yielded results.

The final answer for any farmer as to whether to produce grass silage involves much more than a superficial analysis of the costs of harvesting the grass and the feeding value of the silage. Under some farming conditions, grass silage may be an important link in the entire farming system - a strong link that may tie together all the farming operations into a better soil-conserving and more profitable business.

Especially those farmers who have crop land that is likely to erode when planted to corn for silage may find that using grass for silage increases the land's productivity, increases the total production of milk, and enlarges the farm's business and income. Until this kind of analysis is available the value of data like those in this preliminary report are very limited, except to those who have already decided to make grass silage.

METHODS OF HARVESTING GRASS SILAGE IN NORTHEASTERN PENNSYLVANIA

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THE STUDY

Grass silage has been used for a long time, to some extent, but the great expansion in the storing of grasses and legumes in silos has taken place only in recent years. Producing grass silage is important in the Northeast and in the Pacific North Coast dairy area, especially in the western part of Washington State. This kind of silage is used somewhat in the Lake States, and recently numerous farmers in Maryland, Virginia, and other areas, have tried this method of storing their crops of hay.

In 1945, studies of haymaking practices and methods were made by the Bureau of Agricultural Economics and cooperating Agricultural Experiment Stations in 17 areas in 13 States. In only one area--the North Coast dairy area of Washington, were enough data obtained on grass silage for making an analysis. The results for this area were published in a Washington Experiment Station bulletin. 1/

1/ Methods of Harvesting Hay Fields and Pastures in Northwestern Washington (North Coast Area) 1945, H. H. Stipler, M. T. Buchanan, and A. G. Law. Washington Experiment Station Bul. 502, April 1948.

To supplement the information collected in 1945, data on grass silage were obtained from about 30 northeastern Pennsylvania dairy farms in the summer of 1948. This Pennsylvania area is composed of Tioga, Susquehanna, and Bradford counties in the northeastern corner of the State. The observations covered the practices and methods of haymaking and making grass silage on dairy farms. Most of the farms visited were in Susquehanna County, located in the New York milk-shed.

This area has a high elevation and is hilly, with many rocks on the surface of the soil. The growing season is short and unless the spring is favorable for the early planting of corn, this crop does not yield well. The usual period free from killing frost is from about May 5th to October 5th, or about 150 days. Most of the corn is grown for silage, very little being harvested for grain.

Most of the hay here is of clover-grass mixtures. Ladino is popular and has replaced red clover and Alsike to some extent. The grasses are usually timothy and orchard grass but some farmers have tried smooth brome grass and say they prefer it to orchard grass because it does not get so hard and stemmy by the usual time of first cutting. Most of the hay is grown locally but nearly all concentrates are bought from other areas.

There was no attempt to select a sample representing the usual size of dairy farms in the area; instead, several farms using different harvest methods were observed. Records were obtained from farmers who had made grass silage for several years to get the benefit of their experience.

The farms observed were larger than the average dairy farms in the area and the crop yields were somewhat above the averages for the area. Average yields in the entire area in 1947 were above normal. The yields of ensilage from the hay crop averaged about 6 tons per acre on the visited farms. Census data for Susquehanna County indicate an average yield of clover and timothy hay of 1.20 tons per acre in 1939 and about 1.56 in 1944. With a yield of 1.5 tons per acre, the grass-silage equivalent at 65 percent moisture is about 3.5 tons per acre. Yields on these visited farms in 1947 were probably about 70 percent above normal yields for the area as a whole, and about 30 percent above normal for these farms.

These farmers were progressive. The amount of machinery on their farms was larger than average for farms of the area, and the organization of the work in most cases was very good. As a result, the crews on these farms, whether using the loader-silo filler method or the field chopper method were probably somewhat more efficient than the crews on most of the other farms that used these methods.

FARM ORGANIZATION IN SUSQUEHANNA COUNTY

Of the land in farms in Susquehanna County, in 1944, about 50 percent was pastured, 29 percent was harvested cropland, and 22 percent was woodland not pastured, or was idle land, crop-failure land, or land not used(table 1).

In 1944, about 67 percent of the cropland was in hay, 14 percent in small grains, and 14 percent in corn. Approximately 72 percent of the hay acreage was clover and timothy. The larger parts of all the field crops in the area, exclusive of wheat, were fed to dairy cattle.

Table 1.- Use of farm land in Susquehanna County, Penn. 1939 and 1944

Item	Unit	1939	1944
Average size of farm	Acres	128	152
Land in farms	Acres	413,552	415,779
Crop land harvested	Acres	113,061	119,196
Crop failure or idle	Acres	19,328	9,323
Crop land pastured	Acres	1/ 86,854	7,502
Woodland pastured	Acres	2/ ---	39,796
Other land pastured	Acres	2/ ---	159,852
Woodland not pastured	Acres	2/ ---	59,715
All other land	Acres	2/ ---	20,395
Crops harvested:			
Mixed small grains	Acres	525	657
Oats	Acres	14,240	15,208
Rye	Acres	90	80
Wheat	Acres	532	593
Corn for all purposes	Acres	15,243	16,412
Corn harvested for grain	Acres	1,723	791
Crops harvested for hay	Acres	75,564	80,411
Hay crops harvested:			
Total of all types	Acres	75,564	80,411
Total of all types	Tons	86,411	123,630
Acreage and tonnage by type of hay			
Clover and timothy	Acres	51,184	57,727
	Tons	61,481	90,328
Alfalfa	Acres	1,131	2,964
	Tons	2,046	5,734
Soybeans	Acres	180	548
	Tons	332	1,046
Small grain	Acres	1,715	56
	Tons	2,044	99
Other tame	Acres	20,446	17,828
	Tons	19,861	25,209
Wild	Acres	908	1,288
	Tons	647	1,214

Source of data - U. S. Census reports for 1940 and 1945.

1/ The 1939 and 1944 figures are not strictly comparable since the 1939 figures include land pastured which could have been plowed and used for crops without additional clearing, drainage, or irrigation. This land may not have been plowed within 7 years of 1939.

2/ Not obtained.

Tables 1 and 2 contain census information relative to the crop and livestock enterprises in Susquehanna County.

The value of dairy products sold accounted for about 67 percent of the value of all farm sales in 1944.

Until about 1938, corn silage accounted for almost all of the silage made in this area. Some hay crops have been harvested for silage for more than 25 years but most farmers who now harvest hay crops for silage have begun to do it within the last few years.

FARMER EXPERIENCE AND OPINION CONCERNING GRASS SILAGE

Several reasons for the recent increase in the use of grass silage are given below.

1. In recent years use of better hay mixtures and more fertilizer and lime, and an adequate moisture supply, have brought heavy hay yields. Wet weather in spring and early summer has emphasized the farmer's problem of curing hay. In several recent years the weather has caused delay in harvesting the first cutting and hay damage and losses have been considerable. Late wet springs have been unfavorable to corn planting, and in such years the yields of corn silage probably have not been over 65 to 70 percent of the average for the period 1935-45. Many farmers reported yields in 1947 of only 5 or 6 tons of corn silage material per acre, whereas they usually produced from 8 to 12 tons per acre.

2. New techniques, methods, and practices have made important contributions toward increasing the quantity of hay harvested for grass silage. Probably, the most notable development in techniques is the practice of wilting the material to about 65 percent moisture and, in most cases, not using any preservatives. Many farmers had tried putting material with more moisture, perhaps 75-80 percent, in the silo and the result was silage of poor quality. Some operators ensiled the material after it was too dry to make silage of the best quality. Putting the material in the silo when it is on the wet side is better than doing it when the material is too dry. Some of the farmers said that material with 75 percent moisture made fairly good silage when it was chopped short and packed well, if there was some means by which the free juices could be drained off. The pressure of settling will usually force the free moisture content of the material down to a tolerable level, but sometimes grass silages are still very high in moisture after the seepage from the silo has stopped. Most of the farmers thought that material ensiled at about 65 percent moisture content resulted in the best quality of silage. Unnecessary moisture increases the pressures on silos, and in some cases a silo was barely able to stand the pressure even when the silage contained only 65 percent moisture. One farmer who ensiled alfalfa that was estimated to contain about 79 percent moisture had no drain from the bottom of his silo and the water escaping through the doors muddied the soil over a place of 40 feet in radius around the silo. This farmer had added molasses to the green material, and probably a large part of it was lost with the escaping juices. But he said he had used unwilted alfalfa and molasses in this way for several years and had produced good silage, although it had a very strong odor.

Table 2.- Livestock and value of product for farms in Susquehanna County, Penn., 1939 and 1944

Item	Unit	1939	1944
Farms	Total number	3,227	2,739
Cattle and calves	Number of farms reporting	2,631	2,293
	Total number reported	50,384	57,246
	Number per farm	19.2	25.0
Cows and heifers 2 yrs. and older	Number of farms reporting	2,551	2,212
	Total number reported	33,725	37,974
	Number per farm	13.2	17.2
Cows and heifers milked	Number of farms reporting	2,557	2,230
	Total number	30,496	32,061
	Number per farm reporting	11.9	14.4
Value of dairy products sold	Number of farms reporting	2,124	1,897
	Total dollars reported	2,654,409	6,232,863
	Dollars per farm reporting	1,249	3,286
Total value of farm products sold or used by farm household	Number of farms reporting	3,104	2,626
	Total dollars reported	4,382,182	9,252,006
	Dollars per farm reporting	1,412	3,523
Value of dairy products sold as a percent of the value of all farm products sold or used by farm households	Percent	60.6	67.4

3. Adequate power units for ensiling crops are now available on a great many farms that did not have them years ago. The silo filler cannot be operated satisfactorily by animal power, so farmers with only animal power had their silos filled by custom operators or arranged for powering their own silo filler.

4. Use of the field chopper has increased. Its use eliminates much of the back-breaking work in harvesting hay and silage corn that is necessary when the loader-silo-filler method is used. Furthermore, the field chopper handles a large tonnage in a short time.

5. In hilly areas, as well as in some other areas, erosion is a serious problem. In such areas farmers are trying to find a substitute for row crops. In northeastern Pennsylvania silage corn is the only row crop of any importance, and many farmers have been trying to find a close-growing crop that can be substituted for silage corn. There, corn is usually followed by small grain used as a nurse crop for spring-seeded hay crops, and many of the corn fields are left bare with the soil subject to sheet erosion from the time the silage is cut until spring oats or wheat is sown. Several of the farmers said that if land could be kept in close-growing crops by eliminating corn from the rotation, yields could be increased substantially over a period of years. These possibilities are extremely important there and need further study. Some farmers who are growing grass silage said they do not intend to raise any more corn, and have gone so far as to sell their corn planters, cultivators, and row-crop binders.

6. Some dairymen said that grass silage was cheaper to produce than corn silage, and that they used it partly because it had a higher carotine and protein content. However, it should be remembered that corn silage usually has a higher carbohydrate content than grass silage, and so can be substituted for a greater number of pounds of grain in the ration. Although some farmers hope to eliminate the production of corn silage, most of those interviewed plan to produce and feed both corn and grass silage.

7. Several farmers said that where trees or bushes surrounded fields the hay in outside swaths is difficult to cure in a reasonable time. Under such conditions they often "opened-up" these fields by cutting a few swaths around them and putting the grass in silos, even though the remainder of the material on these fields was cured for hay.

8. Material is usually cut earlier for grass silage than for hay. Getting the first crop off the land early in the season usually means a definitely higher yield from the second cutting. For high-quality silage, hay crops should be cut about 2 weeks before the usual time for cutting hay. On some farms, especially in recent years, spring moisture has been abundant and during this time pasture has been in excess of needs. Pasture clippings are sometimes used at this season for grass silage. Also, in the spring, part of a pasture may be fenced-off with electric fence and used for silage; later in the season cattle are allowed to graze the entire pasture.

9. Feeding grass silage may improve the color of milk.

10. Some of the farmers thought that feeding grass silage had improved the condition of their cows.

11. Some said that using grass silage results in a better distribution in the use of their labor supply, and that the danger of not having an adequate feed supply is less than when all silage is made from corn.

12. The operators of two or three large dairies thought that feeding grass silage had eliminated, or lessened, breeding difficulties.

13. Some farmers reported that with corn silage the cattle went "off feed" about midwinter for periods of varying length, but that this could be prevented by changing from grass silage to corn silage or from corn silage to grass silage.

Some farmers reported that grass silage left a disagreeable, penetrating odor in the barns. Farmers generally agree that the harvest work is strenuous, unless field choppers are used. Some silos are not suitable for storing grass silage, although they are adequate for storing corn silage. In connection with shifting from corn to grass silage some farmers mentioned the difficulty of establishing a new cropping system, or rotation, if corn silage was dropped altogether. However, no serious problems appear to be involved in such a shift.

SILAGE AND HAY CONVERSION WEIGHTS

All calculations for grass silage in this report, unless otherwise stated, are based on unsettled green material at 65 percent moisture. One ton of 20 percent moisture hay contains about 0.8 of a ton of dry matter, and is equivalent to about 3.2 tons of 75-percent moisture green material, or 2.3 tons of 65-percent moisture green material. One ton of 65-percent moisture silage is equivalent to about 0.45 ton of 20-percent moisture hay, or 0.35 of a ton of dry matter. Mixed grasses ensiled at 65 percent moisture lose about one-sixth in weight and 8 to 12 percent in dry matter content, after they are put in the silo. The loss in weight is brought about partly by seepage from high moisture crops and partly by fermentation. Bacterial fermentation causes considerable loss of dry matter and weight.

After corn is ensiled it usually loses from 4 to 8 percent in weight. The loss is higher in large silos. Grass silage packs tigher than corn silage, because it has a higher moisture content when ensiled.

MATERIALS USED FOR GRASS SILAGE

Most grass silage in this area was made from early cuttings of hay crops, when the changes of weather damages are usually greatest. On the farms studied, some was made from the second cuttings of regular hay crops, and some from such crops as oats, alfalfa, soybeans, soybean-sorghum mixed, and soybean-millet mixed. Over 90 percent was made from the first cutting of legume-grass mixtures grown as regular hay crops. In 1948, most of the grass silage was stored between June 12 and June 20.

The usual mixture was ladino with timothy or orchard grass, or both. Some farmers used alsike or red clover in the mixture but ladino has replaced other types of clovers to a considerable extent. Some farmers are now using smooth brome grass in the mixture to replace orchard grass or timothy. Ladino clover has a high moisture content and a somewhat longer time is required to wilt it properly than is required for other types. Because grasses have a higher carbohydrate content than the legumes it is believed that a grass-legume mixture makes higher quality silage than legumes alone. The acid content of silage made solely from legumes is likely to be low unless some preservative is added.

One farmer had fed silage made of clover-grass mixtures, soybean-millet mixtures, and of soybeans and sorghum mixtures, as well as corn silage. He said his cows produced more milk when they were fed silage made of soybeans mixed with sorghum. This silage has a high feed value and fewer pounds per cow are required than of other types of silage.

Crops such as soybeans and sorghum, soybeans and millet, or soybeans and sudan, make good silage but in this area they are used primarily where the regular hay crop is light, or more frequently where farmers fail to get silage corn planted. Various catch crops are used under some circumstances but the first cutting of regular hay crops will probably continue to furnish the bulk of grass silage produced in the area.

METHODS OF HARVESTING GRASS SILAGE

In 1948, all but one of these farmers used the "wilt method." One man used a field chopper and elevated the cut alfalfa directly into a trailed wagon. The others used a swing-type windrower or swather attached to the mower cutter-bar which leaves the green material in windrows. The green windrowed material was left until it wilted to about 65 percent moisture. It was then loaded with a loader and chopped with a silage cutter, or it was chopped from the windrow with a field chopper. It should be noted, however, that in some areas the green material is sometimes loaded by hand and sometimes carried to the ensilage cutter with buckrakes.

In the spring of 1948 probably 15 to 20 percent more material was harvested in this area for grass silage than in the spring of 1947. Preservatives were used by about 5 percent of these farmers. Probably about 5 percent of those who made grass silage used forage harvesters but farms on

which these were used accounted for 10 percent or more of the grass silage harvested. In 1948 data were collected on 325 Vermont dairy farms by specialists from the University of Veromt. A preliminary examination of these records indicates that the above percentages are fairly applicable to the production of grass silage on Vermont dairy farms.

Loader and Silo-Filler Method

Tractor mowers were used on all grass-silage farms visited. All the farmers who used mowers to cut hay crops for silage had swing-type windrowers attached to the cutter-bars, and mowing and windrowing were done in one operation. When a windrower is attached to the cutter bar, the side draft is increased, and unless the knife head or pitman is kept in proper alignment it may be broken.

Side-delivery rakes are sometimes used for windrowing the material, but if the soil is rocky these turn more stones into the windrow than do swing-type windrowers. It is important to prevent this because rocks cause breakage in the silo-filler or field chopper. When a windrower is used it is not easy to form a windrow on the uphill side of the land; however, windrowers were used successfully on farms in this hilly area.

Windrowers were used primarily because of the many stones but they also saved time and labor by eliminating the need of raking. One farmer who used a hay loader loaded the material directly from the swath. Loading and unloading material that has been windrowed with a side rake is harder than loading directly from the swath or from windrows made by swing-type windrowers, because a side rake turns the hay into a ropelike mass that is difficult to untangle.

Although no grain binders were used to harvest grass silage on these farms, in this area generally crops such as timothy, soybeans, sweetclover, Sudan, or cereals, may sometimes be more conveniently cut with grain binders. This method has been used to some extent in other areas. Loading and pitching bundles into a silage cutter is less hard work than loading with hay loaders and pitching off by hand.

The mowing and windrowing was generally done in the late afternoon or evening and the grass left to cure until some time the next day. This method seemed to fit conveniently into the working schedule on dairy farms in this area. The green material was sometimes left in windrows 20 hours or more but there probably was little reduction in moisture content during late evening, night and early morning. In 1948, from June 12 to June 20, when most of the grass silage was harvested in this area, probably about as much curing occurred when handled this way as occurred when the material was left out only 2 or 3 hours in warm dry weather.

In 1947, farmers using the loader-silo-filler method stored an average of about 170 tons of ensilage material per farm. About 110 tons were grass silage and 60 tons were corn. With average yields, corn silage would probably have amounted to about 80 tons per farm. If the 170 tons of ensilage material made about 140 tons of settled silage it was about enough to feed 26 cows about 45 pounds of silage each day for 8 months. This gives some indication of the usual size of operations on farms using this method.

The unchopped material is usually loaded with a "green-crop loader" or regular hay loader. In this area, the push-bar type was usual, but sometimes loaders of the rope-and-slat type are used. When the push-bar type was used, the push-bars were often lowered to a position close to the deck to facilitate loading the green material.

The loader-silo-filler method of harvesting grass silage is adapted for use on dairy farms where the tonnage of silage is too small to justify buying a field chopper. Where hay loaders are used for harvesting hay, little or no new equipment may be needed for harvesting grass silage, as most dairy farmers already have a silage cutter that was bought for harvesting corn.

With the loader-silo-filler method the typical set-up was 3 workers, 2 tractors, 1 hay or green crop loader, 1 trailer, and a silo-filler.

On most of the farms using this method both tractors were owned by the particular farmer concerned, although in a few cases one tractor was obtained from a neighbor on an exchange basis. One farmer used only 1 tractor; on his farm each trailer load of green material was loaded and pulled to the silo, and the tractor was uncoupled from the load and used to power the silo filler. This changing of tractor for various jobs caused delay and reduced the amount of silage stored in a given time. On the farms studied no electric motors were used for powering silo fillers, but on one field-harvester farm an electric motor was used to power the blower.

The fixed costs of machinery and equipment per ton of silage are relatively low when the loader-silo filler method is used. The loader is used on hay as well as on grass silage and the silo filler is used on some silage corn on most farms and often for chopping straw. In the Northeast, where winters are long and snows are frequent, the dairy men like to have the bedding materials stored in the dairy barn. Straw can be efficiently stored in barns by threshing the grain with a stationary thresher and letting the straw go directly from the stacker pipe into a silo filler which chops and blows it into the barn. This practice increases the annual use of silo fillers and reduces the fixed cost per hour of operation.

Workers spent an average of about 7 hours a day in harvesting grass silage. With the loader-silo-filler method they stored an average of about 2.6 tons an hour, or about 18 tons a day. About 1.16 man hours per ton were used to put the material in the silo after it had been windrowed. Mowing and windrowing required about 0.75 man hour per acre, or about 0.12 hour per ton, when the windrower was attached to the cutter bar of a tractor mower. About one man-hour per acre is used for mowing and windrowing when windrowing is done as a separate operation with a tractor-drawn side-delivery rake.

On most farms, the purchase price of machinery and equipment used with this method (excluding row binder), was usually between $750 and $1,200 per farm, but the equipment was bought at various dates and at various prices. One farmer reported paying $600 for a silo filler which contained parts for processing mixed feeds, not ordinarily found on silo fillers. The purchase prices for specified items of machinery and equipment used with this harvest method are shown in table 3.

The average annual machine cost of using a row binder was about $50. The average annual machine cost of using a silo filler was about $44, and in this area they probably operate about 65 hours per year (table 4).

Table 3.- Purchase prices of equipment and machinery used to harvest grass silage by the loader-silo-filler method 1/

Number	Item	Years		
		1935-39	1945	1947
		Dollars	Dollars	Dollars
(1)	Mower (tractor)	138	170	202
(1)	Windrower (swing-type)	18	25	30
(1)	Loader (regular-not green crop)	150	185	228
(1)	Trailer	100	125	165
(1)	Silo filler and pipe	311	370	445
(1)	Row binder (tractor, one-row without bundle loader)	375	450	550
	Total (excluding row binder)	717	875	1,070
	Total (including row binder)	1,092	1,325	1,620

1/ In some cases, side rakes were used. Prices for side rakes in the periods specified in this table were $129, $151, and $196, respectively.

Table 4.- Estimated annual costs of using one-row tractor binders and silo fillers (excluding power costs) based on 1947 purchase prices and operating costs

Item	Unit	Row binder	Silo filler
Purchase price	Dollars	425.00	350.00
Estimated life	Years	15.00	15.00
Depreciation	Dollars	28.35	23.35
Interest and taxes	Dollars	11.65	9.35
Housing	Dollars	5.00	5.00
Repairs and service:			
Cash	Dollars	2.50	3.00
Farm labor	Dollars	2.50	3.00
Grease and miscellaneous	Dollars	.50	.50
Total	Dollars	50.50	44.20

When the loader-silo-filler method was used, it cost an average of about $1.55 to ensile a ton of ensilage material, or $1.90 per ton of settled silage. The harvesting cost of ensilage material averaged about $4.45 per ton of dry matter of ensilage material with a moisture content of about 65 percent (about 2.86 tons of silage equal one ton of dry matter (table 5). In terms of settled silage this is equivalent to a cost of about $5.20 per ton of dry matter. Man labor accounted for about 52 percent of the total harvest cost, power 28 percent, and machinery and equipment 20 percent. A decision to arbitrarily apportion joint costs, and to charge family labor at the hired rate influences the costs obtained, but in cases where labor is hired these give a relatively accurate picture of the cost of this method, compared with the costs of the field-harvester method.

Table 5.- Average physical inputs and harvesting costs per ton of silage and dry matter by the loader-silo-filler method (based on a per acre yield of 6 tons of green material at 65 percent moisture)

Item	Rate per hour	Per ton of 1/ unsettled silage		Per ton of dry matter at time of ensiling	
		Hours	Cost	Hours	Cost
	Dollars	Hours	Dollars	Hours	Dollars
Mower and windrower	0.40	0.12	0.05	0.34	0.14
Loader	.60	.16	.10	.46	.29
Trailer	.02	.39	.01	1.12	.03
Silo filler	.70	.16	.12	.46	.34
Tractor 2/	.65	.69	.45	1.97	1.29
Man labor	.65	1.28	.83	3.66	2.37
Total	---	---	1.56	---	4.46

1/ For settled-silage basis multiply by 116 percent.

2/ Full time of the tractor that pulled the trailer plus the actual running time of the motor of the tractor which powered the silo filler.

The main advantage of using the loader-silo-filler method is the low investment in machinery and equipment. The main disadvantage is that the work is heavy and a person must be strong if he is to work for a considerable time at placing the material on a wagon or trailer as it comes from the loader, or at pitching the material into a silo filler. In this area it was hard to get hired labor to put up silage by this method. Most of the farms on which hay crops were harvested for silage had a regular hired worker, but unless the farmer had one or more sons old enough to do part of the work of ensiling he was likely to hire an additional worker at this time.

Two operators who were using this method plan to buy field choppers. Each harvests 300 or more tons of silage annually.

The Field-Chopper Method

The field chopper is adapted for use on farms that produce a large tonnage of silage or do custom work for others.

In this area probably about 5 percent of the farmers who harvested hay crops for silage had field choppers. As these machines were on large dairy farms they probably harvested as much as 10 or 12 percent of the grass silage in the area. There were 12 field choppers on the Northeast dairy farms studied in 1948. The operations of one dairy were so much larger than those of the usual dairy that data for this organization was not included in computing the averages shown in this report.

The quantity of ensilage material harvested on the other farms that used field choppers ranged from about 250 to 1,200 tons per farm. The farm on which 1,200 tons were harvested had two field choppers; one of the machines had a row-crop attachment only, which was used only for corn silage, and the other had only the hay pick-up attachment, which was used only for making grass silage. Actually they were seldom, if ever, both in use at the same time, and one machine with both attachments could have easily handled all the ensilage material harvested on this farm.

On the farms that had only one field chopper each, an average of about 385 tons of ensilage per farm was harvested in 1947 (including both grass and corn). If this made about 320 tons of settled silage it was enough to feed about 58 head of cattle - about 45 pounds per cow per day for 8 months. One farmer produced about 200 tons of silage on his own farm and custom harvested 6 acres of corn for silage and about 45 acres of grass for silage.

No hay was chopped on the farms studied but one farmer installed a barn curer (ducts and fan, but no supplemental heat) in 1947, and intends to chop his hay in 1948. Excluding the two large farms each with more than 100 cows, the average amount of silage handled per field chopper in 1947 was about 270 tons of grass silage and 115 tons of corn silage. Corn silage yields were much below average that year and the acreage harvested would normally have produced enough corn silage to amount to 150 tons or more, instead of 115.

On the farms visited 80 percent of the field choppers had mounted motors, and motors had been ordered for the other farms. The maximum belt horsepower rating of the mounted motors was usually between 30 and 40 horsepower. One farmer used a 15 HP motor from his combine to power the field chopper; this motor did the job fairly well. One farmer chopped alfalfa directly from the standing stalk, all the others used the "wilt" method. All of the other farmers who had bought field choppers with cutter-bars on them had removed the cutter-bars. A farmer who used the machine with the cutter-bar attachment first, found that the alfalfa wrapped around the power-take-off shaft that operated the cutter-bar.

In all cases studied, except one mentioned above, hay crops were cut with tractor mowers equipped with swing-type windrower. On one large farm where alfalfa was grown on large fields a side-delivery rake was pulled behind the tractor mower (equipped with windrower), by the same tractor that pulled the mower and windrower. The side-delivery rake was put in gear every other round, and two of the windrows made by the swinging windrower were thrown together. This was extremely heavy alfalfa, producing 8 or 9 tons per acre of green material at 65 percent moisture content.

The ground was level and free of rocks and the field choppers handled these windrows containing the green material from the 14-foot swath with no difficulty, but the chopper did move somewhat slower then when 7 foot windrows were chopped. This could not be recommended as a general practice, especially on hilly land.

When the material was cut and windrowed, a four-man crew was ordinarily used to ensile it. Of the 12 crews used with field choppers, two were made up of 3 workers each, one had 5 workers, and the remaining 9 crews had 4 workers each. The extra man in the crew of 5 was used on the farm where alfalfa was chopped directly from the standing stalk. He was riding the trailer behind the chopper, keeping the material level, and frequently getting off to remove the material that had wound around the power-take-off shaft to the cutter bar. He also helped to uncouple the filled trailer from behind the chopper and coupled the empty trailer in place when a load was ready to be sent to the silo.

None of the crews used anyone entirely for tramping the material as it was put in the silo. When field choppers were used, from about 5 to 13 tons were stored per hour, the average being about 9 or 10 tons. On the farm where 5 tons per hour were stored, a crew of three men was used. In this case one man was on the tractor that pulled the chopper, one was on the tractor that pulled the trailers to the silo, and one man staid at the silo to unload a trailer while the other one was being filled or taken to or from the field. The trailers were unloaded by hand, but this farmer had just bought a mechanical unloading device which was received the day of the interview. He was using a power-take-off model chopper on which he had mounted the motor from a 6 foot combine. This motor helped, but the capacity was less than that of the choppers with larger mounted motors. He used a two-plow tractor for pulling the field chopper and a trailed wagon, but the tractor was a little light for doing this job on the steep hills. A two-plow tractor will pull a field chopper with mounted motor and a loaded trailer if the ground is level, but a three-plow tractor or a larger one is

really needed for this work if the land is hilly. If a field chopper of a power-take-off model is used, the tractor should be about one-plow size larger than when a mounted motor-type chopper is used, if the job is to be done satisfactorily.

Field choppers accomplished more in a day when trucks were used for hauling. This was mainly because a tractor pulled the field chopper at a lower speed when a trailer was pulled behind the chopper. Part of the difference was due to the time taken to uncouple the loaded trailer and fasten on an empty one, etc. All farmers who used tractors for hauling, hooked a trailer behind the chopper and used only one extra tractor to pull the trailers from the field to the silo. If an additional man and tractor had been available, so that the trailers could have been pulled along-side the chopper instead of being trailed, the number of tons handled per hour would have been larger, but this would have required four tractors and few farmers have this many.

Trucks with high sides, or trailers, were usually used for taking the chopped material to the silo and most of these hauled about 3 tons per load. The speed at which the green material could be taken from the field chopper to the silo often limited the speed of the entire operation. Under favorable conditions the chopper handled a 3-ton load in 12 to 15 minutes. The average amount stored in an hour was about 9 or 10 tons, although two of the farmers stored about 12 to 13 tons per hour.

Most of the trucks or trailers used with the field-chopper outfits were equipped with some kind of mechanical unloading device. With each of several of the field choppers two trucks were used for hauling and some of the trucks had dump bodies. Two of the trucks with bodies of the regular type had three boards, each placed horizontally on edge across the truck bed, and one above the other, just back of the truck cab. A rope was fastened to each end of each board. Power for unloading was furnished by an electric motor. The ropes attached to each end of a board were fastened around a winch that was powered by the electric motor. The ropes were wound around the winch thus pulling one board at a time to the rear of the truck. About one-third of the load was brought gradually to the rear of the truck with each board.

Those farmers who did not use trucks used two large trailers each, some homemade and some factory built, with the cost ranging from about $150 to $350 each. Three-fourths of the trailers had unloading devices of some kind. Most of these devices were composed of a canvas which moved the ensilage material to the rear of the trailer where it fell into the blower or silo filler. This was done by winding the canvas around a pipe located at the back of the trailer. Some farmers used a large canvas and made two or three large folds in the canvas with silage stacked on each fold. In unloading, one-third or one-fourth of the load at a time is moved to the rear. The folds should always be underneath and toward the back of the truck or trailer. The pipe was turned by means of a fitting attached to a shaft which was driven by a special gear-box unit, powered by a small gasoline motor. One farmer used a small electric motor for this purpose. Some farmers had tried putting a false endgate in front of the load near the

cab and pulling this to the rear of the truck or trailer for unloading the material. They said that it was unsatisfactory, for the material often became tightly jammed under the endgate as it was pulled to the rear, and the work was delayed while the material was being moved from under it.

Unloading was done very quickly in most cases. The time required to unload a 3 ton load ranged from about 5 to 12 minutes. If no unloading devices were used it took somewhat more time.

In a few cases where field choppers were used the chopped material was run through a silage-cutter instead of a blower. One farmer, following this practice, said he liked to do it because the material could be cut in shorter lengths. Some farmers prefer to use a stationary chopper because it has more capacity than a blower. One said that he had an augur-type blower that worked well on corn silage but not so well on grass silage, so he used the silo filler when storing grass silage. Some other farmers said they already had silo fillers that were satisfactory, so they did not feel justified in spending more money for blowers.

Where motortrucks were used for hauling, the equipment consisted of a tractor and field chopper, two trucks, and a blower or silo filler powered by a tractor (in one case a 35 horsepower electric motor was used on the blower).

When trailers were used, usually one trailer was pulled behind the chopper while another tractor took the filled trailer to the silo to be unloaded and brought it back to the field. With this arrangement, including the tractor used for powering the blower, a total of three tractors were usually used. Some farms that produce enough silage to justify the purchase of a field chopper do not have as many as three tractors; they may find it appropriate to use an electric motor for powering the blower, providing the wiring is heavy enough to carry the load for a motor of the size needed.

When the field-chopper method was used the harvest labor ranged from about 0.3 to 0.6 man-hour per ton, with an average of about 0.4. This was about one-third as much labor as was used with the loader-silo-filler method. These farmers had large tonnages of silage and had efficient set-ups. If smaller farmers used the field-chopper method they would undoubtedly need somewhat more man labor, because they would have less equipment for hauling and unloading. The work with the field chopper is much less strenuous than that required with the loader-silo-filler method.

Farmers in northeastern Pennsylvania generally preferred mounted motor types of field choppers for harvesting grass silage. The 1948 purchase price of such field choppers ranged from $1,800 to $2,500. The purchase price of power-take-off models in 1948 were from $500 to $700 less than those with mounted motors. At that time the "corn head", or row attachment, cost from $200 to $450, and a blower and pipe cost $300 or more.

HARVEST COSTS FOR TWO METHODS

With man labor charged at $.65 per hour and other costs at 1947 prices, if 150 tons of silage are harvested annually, the harvesting costs are $1.75 per ton with the loader-silo-filler method and $2.70 per ton with the field-chopper method. But if 300 tons of silage are harvested annually, the harvest cost with the field-chopper method is about $1.75 per ton of silage, which is only slightly higher than the cost with the loader-silo-filler method (table 6). When about 500 tons of silage are handled annually, the harvest cost per ton is about $1.50 with the loader-silo-filler method and $1.30 with the field-chopper method. The lower cost with the field chopper results chiefly from spreading the fixed cost of the field chopper over a larger volume of work. In most areas it would be necessary to ensile about 300 tons of silage annually (or an equivalent amount of use) if the purchase of a field chopper is to be justified on the basis of cost per ton of material harvested. The above costs are per ton of ensilage material, or per ton of unsettled silage.

Table 6.- Physical inputs and 1947 harvest costs per ton of ensilage material and per ton of dry matter by field-chopper method (based on a yield of 6 tons of green material per acre at 65 percent moisture and 300 tons of ensilage material per farm)

Item	Per ton of unsettled silage 1/		Per ton of dry matter at the time of ensiling	
	Time required	Cost	Time required	Cost
	Hours	Dollars	Hours	Dollars
Mower and windrower	.12	.05	.34	.14
Field chopper	.10	1.09	.29	3.12
Trailer and canvas	.20	.02	.57	.06
Motor and gear box for unloading	.10	.07	.29	.20
Blower at silo	.10	.06	.29	.17
Tractor	.30	.20	.80	.52
Man labor	.40	.26	1.14	.74
Total	---	1.75	---	4.95

1/ To convert to settled-silage basis multiply this by 116 percent.

The level of use at which it is economical to substitute the field-chopper method for the loader-silo-filler method depends on the machinery, power, and labor available to the individual farmer. The wage rate paid for harvest hands is important in determining which harvest method will give the lower harvest cost.

If the wage rate is about $1 an hour, as in the Pacific Northwest, with 300 tons of silage harvested annually, the harvest cost with the field-chopper method is about $0.35 per ton less than with the loader-silo-filler method. With this wage rate, the harvest costs per ton with the two methods are about equal when 225 tons are handled annually. At this wage rate, with larger tonnages, the harvest cost per ton is lower with the field-chopper method than with the loader-silo-filler method.

The main advantage of the field-chopper method is the small amount of man labor required per ton and the speed with which the harvesting is done. A four-man crew, working about 7 or 8 hours a day with a field chopper and complementary equipment, can store 60 to 90 tons of ensilage material in a day. To store the same quantity of ensilage, with a three-man crew using the loader-silo-filler method, would take about 4 or 5 days.

On most dairy farms studied in the Pennsylvania area there was usually at least one regular hired worker, and when grass was being harvested for silage an additional man, and sometimes two, were hired. Most farmers said that it was much easier to get these additional hired workers when the silage was to be harvested with a field chopper than when it was to be harvested with a loader and silo filler.

The main disadvantage with the field-chopper method is the heavy investment required (tables 7 and 8). This method (when mounted-motor types are used) requires an initial investment of about $3,000, and the field chopper, which costs around $2,200 in many cases, is not used more than 6 or 7 days a year in the Northeast where these choppers are not generally used for chopping hay. Thus farmers also have additional investments in loaders, buckrakes, balers, or other equipment used in haymaking.

Loading and unloading grass silage by hand, or loading with hay loaders and unloading by hand, is very heavy work so there is a great need for machines and equipment that can do this job adequately, and yet not require too heavy investment.

USE OF PRESERVATIVES

Molasses, acids, ground grain, salt, and bacterial cultures, are among the preservatives that have been used in making grass silage. The real value of salt and bacterial cultures as grass silage preservatives has never been proved. When molasses is used, 40 to 70 pounds per ton is the usual application, and applications of ground grain may be at the rate of about 100 to 200 pounds per ton.

Table 7.- Purchase prices of equipment and machinery used to harvest grass silage by the field-chopper method (at 1945 and 1947 prices)

Number	Item	Year 1945	Year 1947
		Dollars	Dollars
(1)	Mower (tractor)	170	202
(1)	Windrower (swing type)	25	30
(2)	Trailers (without unloading devices)	200	240
(2)	Sets of canvas, one gear box and one gas or electric motor (for unloading)	200	250
(1)	Field chopper with mounted motor	2,000	2,200
(1)	Row crop attachment for field chopper	250	300
(1)	Blower and 45 feet of pipe	300	350
	Total (without row crop attachment)	2,895	3,272
	Total (including row crop attachment)	3,145	3,572

Table 8.- Estimated annual cost of using a mounted-motor type of field chopper in 1947

Item	Unit	Without row crop attachment	Including row crop attachment
Purchase price	Dollars	2,200.00	2,500.00
Estimated life	Years	12.00	12.00
Depreciation 1/	Dollars	183.33	208.33
Interest and taxes 2/	Dollars	60.50	68.75
Housing	Dollars	15.00	16.00
Repairs and services: 3/			
Cash repairs	Dollars	15.00	16.00
Farm labor for repairs and services	Dollars	3.00	4.00
Fuel and oil for auxiliary motor 4/	Dollars	12.00	12.00
Grease and miscellaneous	Dollars	2.00	2.50
Total	Dollars	290.83	327.58

1/ Straight-line depreciation. Purchase price divided by average years of life.
2/ Interest computed at 5 percent of one-half of purchase price.
3/ Repairs and service charges are based on repair bills reported by farmers using this relatively new equipment; these charges might be considerably higher with older equipment.
4/ An average of about 1.5 gallons of fuel per hour for 35 hours; gasoline charged at about 23 cents a gallon.

In 1948, most of the grass silage in northeastern Pennsylvania was made without adding any preservative. If a grass-legume mixture is chopped short and ensiled with about 65 percent moisture content, and the silo is tight, no preservative is ordinarily needed. Specialists in the U. S. Department of Agriculture say that alfalfa can be ensiled alone without any preservative if it is wilted to 65 percent moisture content. A preservative should be added when the crop cannot be wilted sufficiently. These specialists recommend adding preservatives if the green legume material contains more than 75 percent moisture by weight. 2/

About 5 percent of the interviewed farmers used preservatives. Molasses was the only preservative used on the farms visited in 1948. That year, molasses cost the farmers about 40 cents a gallon or about 35 cents a pound. Some farmers said they would have used molasses if it had not cost so much. They believed the improvement in the quality of the silage and the additional feed value would not justify adding molasses to grass-legume mixtures at the 1948 prices for molasses.

There has been considerable discussion in regard to the need for moisture testers by farmers who make grass silage. Of the farms visited only the two largest dairies had moisture testers. When a farmer first makes grass silage a moisture tester would aid him in finding the exact moisture content of the ensilage material; but with experience farmers quickly learn how to know when the material has the correct moisture content for ensiling. If other farmers in the community have previously made grass silage, a farmer who wants to try can easily observe their methods and talk it over with them. As a rule of thumb, farmers say that the correct moisture for ensiling can be learned by squeezing the chopped material in the hand and watching the shape of the mass when the grip is released and the hand opened. If the mass remains in a tight hard ball it is too wet; if the mass springs apart suddenly and straightens out it is too dry; if the mass relaxes gradually and holds most of its shape it is at about the right stage for ensiling. If material with too high a moisture content is ensiled, a very strong odor will develop, but the cows seem to eat such silage satisfactorily. Adding molasses to the material usually means a silage with a more pleasant sharp acid odor.

LEVELING AND PACKING THE SILAGE

All of the interviewed farmers, in 1948, said that their machines were set to chop the material into 1/4-inch pieces, or as short as possible. Although tramping grass silage is recommended, on many farms it was not done until the silo was almost full. Lack of help was usually given as the reason, but several said that if the green material had a 65-percent moisture content and was cut 1/4 inch or less, it would pack well enough without tramping. Some of them leveled the silage after every 4 to 6 tons, as the silo was filled; some leveled it occasionally only after the silo was nearly full. Some tramping was done in nearly all silos when the filling neared the top of the silo. Usually the top layer of material was tramped well as filling was completed but some farmers also tramped the silage once or twice a day for several days after the silo was filled. Some wet the top layer of the material with water each day for a few days after the silo was filled.

2/ For details regarding recommendations relative to the use of preservatives see "Ensiling Hay and Pasture Crops," 1948 Yearbook of Agriculture, pp. 178-190.

It is important that the material be packed and leveled well around the side to exclude air and to avoid spoilage down the side. Some precautions should be taken to level the material near the top. The writer knows of one case in which a metal silo was bent and damaged because the distributor pipe was not adjusted correctly and the silage was not properly distributed and leveled. The blower blew so much of the material to the side of the silo opposite the blower pipe that when the silage settled the extra weight on that side damaged the structure.

The silo filling should be as nearly continuous as possible after the filling begins. If there are 2 or 3 days between loads the material on top will begin to heat and this may cause spoilage.

After the top part is tramped thoroughly, various types of topping material are often applied. A layer of fresh-mowed unwilted long grass or legumes may be put on top. Some top off the silage with a layer of oats, grass seed, or hay chaff containing seeds which soon sprout and form a protective covering. Waterproofing paper or straw is sometimes used. The kind of material is not important as long as air is kept from entering the material and the top layer is not allowed to become too dry.

IMPROVING THE QUALITY OF GRASS SILAGE

In recent years there has been a concerted effort to improve the quality of grass silage. Specialists of the U. S. Department of Agriculture and State Experiment Stations, and County Extension Agents, as well as farmers themselves, have contributed greatly toward the development of techniques and better practices for improving this quality.

The farm papers have done an outstanding job in spreading information about grass silage among the farmers. They have circulated the results obtained from grass-silage production and feeding in various areas, and have printed discussions of technical developments by specialists who are working on grass-silage and dairy-feeding problems in general.

In the Northeast, interest in this subject has been stimulated through a program of competition among the farmers who produce grass silage. In 1948, several farm-machinery companies contributed funds to a Northeast farm paper, which acted as a clearing house for organizations that were interested in prize money given to winners in a competition in the production of quality grass silage. The money was allotted to local farm organizations, fairs, etc., which set up grass silage as a competitive class exhibit. Standards for judging the quality of grass silage (based on such factors as odor. appearance, mold, etc.) were established in connection with this competition. Many farmers developed a keen interest in grass-silage production and feeding.

SUMMARY AND CONCLUSIONS

1. Weather probably has been the most influential factor in getting dairymen in the Northeast to start harvesting hay crops for silage, but the majority of the farmers interviewed in this study said that after they had once fed grass silage they would continue to make it even if the weather were good for curing hay.

2. Most grass silage in the Northeast will continue to be made from the early cutting of hay crops when weather is usually not good for curing hay. It seems likely that the use of grass silage will continue to increase.

3. In harvesting, the substitution of machines, equipment, and power for man labor will continue, and the rate of mechanization will depend mostly on the farm income and, to a lesser extent, on rates of the farm wages.

4. The subject of making and using grass silage needs further investigation especially in regard to its influence on farm incomes, on land use, and on the long-time effects on the yields of crops.

APPENDIX

This section contains miscellaneous data related to problems of growing and handling grass silage. Some of the data were collected in the field survey and some were assembled from published material.

Types of Silos in the Area

Grass silage has stimulated an interest in silo construction and a considerable number of silos have recently been built for storing grass silage. When grass silage was stored in silos built for corn silage, additional hoops or other reinforcements were often considered necessary. The number of hoops on the lower third of the silo were usually about doubled. Specialists in the area recommended that silos in which grass silage was to be stored should be built stronger than those in which only corn silage was to be stored. They differ in their estimates of the comparative pressures exerted, but as the grass material may be stored with a pretty high moisture content it was thought best to recommend additional reinforcement.

Silos in the area were of several types and were made of a variety of materials. They were made of glazed tile, cinder block, concrete block, concrete stave, monolithic concrete, wood stave, and wood stud; a few were made of stone. Some farmers used temporary silos made of snow fences, for storing corn silage. No grass silage was stored in temporary silos in this area but some pit silos were reported to be used successfully for storing grass silage in New York in 1947.

Wooden silos in this area were relatively old. Most silos built in recent years were made of glazed tile, concrete blocks, or cinder blocks.

Silos ranged from about 24 to 50 feet in height and 12 to 20 feet in diameter. Some of the most common sizes were 44 feet by 16 feet, 44 by 14, 40 by 16, 36 by 14, 36 by 14, 36 by 12, 30 by 14, 30 by 12, and 28 by 14. The capacities of silos of specified sizes are given in table 9.

Capacities of Silos

Since many persons want to know the capacity of silos, the following information, prepared by a dairy specialist, is given.

J. B. Shepherd in an article, "Estimating Silo Contents" published in Hoards Dairyman for April 25, 1946, in reference to table 9 wrote that "the table is also suitable for determining the amount of settled grass silage in a silo, since comparative data at Beltsville, and at New Jersey and Michigan State Agricultural Experiment Stations indicate that silos hold about the same weight of grass silage as of corn silage with the same moisture content; exceeding corn silage in weight only when the silo is very large in diameter or when the depth of the silage is unusually great."

The data in table 9 are based on corn ensiled at Beltsville, Md. In Dr. Shepherd's article and in USDA Circular 603 it is stated that "the corn had an average moisture content of 72.4 percent. The silage was made from well eared corn cut after the kernels had started to dent, but before they were fully dented, and while the stalks and leaves were still about three-fourths green."

Dr. Shepherd, when using this table for estimating the weight of settled corn silage, from the experience in making grass silage at Beltsville, says that the following corrections should be made.

1. If the crop is cut before heading out and is ensiled before wilting (75-80 percent moisture), add 5 to 10 percent to the figures in the table.

2. If the crop was overripe when cut or wilted before ensiled

deduct from figures in the table	average silage moisture percent
5 to 10 percent for ----------	69 to 67
15 to 20 percent for ----------	66 to 64
25 to 30 percent for ----------	63 to 61

The above figures are based on the assumption that the material is finely chopped (one-fourth or one-third inch cut) and the top weighted down with several feet of heavy unwilted crop, so the silage will not mold.

3. If the crop was chopped with a 5/8-inch to 3/4-inch or longer cut, deduct 5 percent in addition to all other corrections.

4. If the crop is put into a silo 12 feet or less in diameter or is ensiled without distributing and/or tramping, deduct 5 percent, in addition to all other corrections.

Table 9.- Average weight per cubic foot and the total quantity of settled silage from the top to various depths 1/

Depth of settled silage (feet)	Average weight per cubic foot 2/		Total quantity of settled silage, from the top to the depth indicated, in silos having a diameter of-					
	Silage	Dry matter	10 feet	12 feet	14 feet	16 feet	18 feet	20 feet
	Pounds	Pounds	Tons	Tons	Tons	Tons	Tons	Tons
1	17.7	4.89	0.7	1.0	1.4	1.8	2.2	2.8
2	23.5	6.49	1.8	2.6	3.6	4.7	6.0	7.4
3	26.9	7.43	3.2	4.6	6.2	8.1	10.3	12.7
4	29.5	8.15	4.7	6.7	9.1	11.9	15.0	18.5
5	31.6	8.73	6.3	8.9	12.1	15.9	20.1	24.8
6	33.3	9.20	7.9	11.3	15.4	20.1	25.5	31.4
7	34.7	9.59	9.6	13.8	18.7	24.4	31.0	38.3
8	36.0	9.95	11.4	16.3	22.2	29.0	36.7	45.3
9	37.1	10.25	13.2	18.9	25.7	33.6	42.6	52.5
10	38.1	10.53	15.0	21.6	29.4	38.3	48.6	59.9
11	39.0	10.78	16.9	24.3	33.0	43.1	54.7	67.4
12	39.8	11.00	18.8	27.0	36.8	48.0	60.9	75.1
13	40.6	11.22	20.8	29.8	40.6	53.0	67.2	82.8
14	41.2	11.38	22.7	32.6	44.4	58.0	73.5	90.7
15	41.8	11.55	24.7	35.5	48.3	63.1	79.9	98.6
16	42.4	11.72	26.7	38.4	52.2	68.2	86.4	106.6
17	43.0	11.88	28.7	41.3	56.2	73.4	93.0	114.7
18	43.5	12.02	30.8	44.2	60.2	78.6	99.6	122.8
19	43.9	12.13	32.8	47.2	64.2	83.8	106.2	131.0
20	44.3	12.24	34.9	50.1	68.2	89.1	112.8	139.2
21	44.7	12.35	36.9	53.1	72.3	94.4	119.6	147.5
22	45.1	12.46	39.0	56.1	76.4	99.8	126.3	155.8
23	45.5	12.57	41.1	59.1	80.5	105.1	133.1	164.2
24	45.8	12.65	43.2	62.1	84.6	110.5	139.9	172.6
25	46.1	12.74	45.3	65.2	88.7	115.9	146.7	181.0
26	46.4	12.82	47.4	68.2	92.9	121.3	153.6	189.5
27	46.7	12.90	49.6	71.3	97.0	126.8	160.5	198.0
28	46.9	12.96	51.7	74.4	101.2	132.2	167.4	206.5
29	47.2	13.04	53.8	77.4	105.4	137.7	174.3	215.1
30	47.4	13.10	56.0	80.5	109.6	143.1	181.2	223.6
31	47.7	13.18	58.1	83.6	113.8	148.6	188.1	232.2
32	47.9	13.23	60.2	86.7	118.0	154.1	195.1	240.8
33	48.1	13.29	62.4	89.8	122.2	159.6	202.0	249.3
34	48.3	13.35	64.5	92.8	126.4	165.1	209.0	257.9
35	48.5	13.40	66.7	96.0	130.6	170.6	216.0	266.6
36	--	--	--	--	134.8	176.1	222.9	275.2
37	--	--	--	--	139.0	181.6	229.9	283.8
38	--	--	--	--	143.3	187.1	236.9	292.4
39	--	--	--	--	147.5	192.6	243.8	301.0
40	--	--	--	--	151.7	198.2	250.8	309.6
41	--	--	--	--	--	203.7	257.8	318.2
42	--	--	--	--	--	209.2	264.8	326.8
43	--	--	--	--	--	214.7	271.7	335.4
44	--	--	--	--	--	220.2	278.7	344.0
45	--	--	--	--	--	225.7	285.7	352.6
46	--	--	--	--	--	--	292.6	361.3
47	--	--	--	--	--	--	299.6	369.9
48	--	--	--	--	--	--	306.6	378.5
49	--	--	--	--	--	--	313.5	387.1
50	--	--	--	--	--	--	320.5	395.7

Source: This table was published in USDA Circular 603 "Estimating the Quantity of Settled Corn Silage in a Silo" and in an article "Estimating Silo Contents" published in Hoards Dairyman for April 25, 1946.

1/ Based on the data for 4 Beltsville silos in which the silage contained 27.63 percent of dry matter.

2/ The average weight per cubic foot for all silage above the depth indicated.

Estimating the Settled-silage Content of Silos

The following is from USDA Circular 603. It was also published in Hoards Dairyman for April 25, 1946. The author says that the "table can be used to estimate the settled-silage content of silos. It was prepared from the Beltsville data obtained by actually weighing all the silage as it was fed out of four silos. The average dry-matter content of the silage in the four silos was 27.63 percent, or only slightly below Morrison's average (28.3 percent) for silage made from well-matured dent corn."

Some glazed-tile silos had hoops on the outside. These hoops were about 7 or 8 inches apart at the bottom and about 2 feet apart at the top. The concrete-block or cinder-block types had wire cable from 3/8 to 5/8 inches in diameter for reinforcement. These cables were usually put between every other course of blocks near the bottom, and between every third course near the top of the silo.

In nearly all cases where silos are to be used for storing grass silage, drains should be installed in the bottom or through the foundation wall. Some provision should be made to seal the drain after the flow of excess juices has stopped. This is done in order to avoid the seepage of air.

Of the several farmers in the area who had wooden silos only two reported having used them for storing grass silage. Wooden silos were generally considered unsatisfactory for this purpose. They often were not strong enough to withstand the additional pressures of grass silage and there were losses due to air seepage. One man reported that he used a wooden stave silo for grass silage as an emergency measure, and that the silage was fairly good in the center of the silo, but a large amount had spoiled around the outside. It was reported by some farmers that if wooden silo walls were soaked with water before starting to fill the silo and if the walls were soaked each morning thereafter as the filling progressed, spoilage around the edges could be reduced substantially. This matter needs further investigation.

The difficulty in building wood silos so they are airtight and strong, and the high cost of lumber, were usually given as reasons why wooden silos were not built for storing grass silage.

Cement is often badly pitted by silage acids. A black caulking compound made from a byproduct of chocolate has been successfully used as a substitute for cement.

Some Silo Construction Costs

A glazed-tile silo, about 44 by 14 feet, cost about $1,000 if custom constructed in 1941; the same size and type of silo cost about $1,800 when custom built in the spring of 1948. In addition to these costs about 100 hours of family labor were used in both cases. In the fall of 1947, two farmers hired skilled workmen to build concrete block silos 40 by 14 feet. They each paid about $650 for material and $275 for hired skilled labor, and used about 150 hours of farm labor. Charging farm labor at the current hired farm-labor rate would have brought the total cost to about $1,225 per silo.

Total Cost of Producing Grass and Corn Silage

Based on 1947 costs and yields on the farms studied, the average preharvest cost of clover-grass mixtures at 65-percent moisture was about $5.10 per ton (table 10). The average total cost of clover-grass ensilage material on the farms with field-choppers was about $6.70 per ton. On the farms with loader-silo-fillers the total cost was about $6.80 per ton.

With an estimated yield of 9 tons of corn silage material per acre, the estimated preharvest cost was about $5.40 per ton of silage material. The estimated harvest cost of corn for silage was about $2 per ton when field choppers were used for harvesting and about $1.65 when harvested with a row binder and silo filler (tables 11 and 12). The total cost of corn silage was about $7.40 when harvested with the field chopper and $7.15 per ton when harvested by the row-binder-silo-filler method.

These harvest costs are based upon about 300 tons of silage material annually per field-chopper farm and about 150 to 175 tons per loader-silo-filler farm.

All labor was charged at current hired farm-labor rates. The allocation of some costs are rather arbitrary but may serve as rough guides. The total cost figures do not include any charge for the use of silos, and shrinkage in silage must be taken into account when the cost per ton of settled silage is considered.

Can grass silage compete with corn silage? In this area, under 1947 cost conditions, with yields of 4.5 tons per acre of grass-clover mixtures, the total cost per ton of grass silage appears to be about equal to the cost of corn silage, where corn yields about 9 or 10 tons of ensilage material per acre.

Table 10.- Estimated preharvest cost per acre for specified silage crops grown in the Northeast, based on 1947 price and cost relationships

Crop	Clover-grass mixture		Corn		Soybean-sorghum mixture	
	Item	Cost	Item	Cost	Item	Cost
		Dollars		Dollars		Dollars
Seed (Ladino, orchard grass & timothy)	-------	0.89 1/	0.2 bushels (corn)	1.70	2 bushels (soybeans); 30 lbs. (amber sorghum)	8.00; 3.60
Fertilizer	250 lbs.	4.00	200 lbs.	3.80	200 lbs.	3.80
Manure	4.0 tons	8.00	8.0 tons	16.00	2.5 tons	5.00
Lime 2/	200 lbs	1.00	--------		150 lbs.	.75
Man labor	1.0 hour	.65	13.0 hours	8.45	6.5 hours	4.23
Tractor work	1.0 hour	.65	13.0 hours	8.45	6.5 hours	4.22
Machinery	----------	.50	--------	2.25	----------	1.50
Land use	----------	7.00	--------	7.00	----------	7.00
Other cost	----------	.25	--------	1.00	----------	1.00
Total preharvest cost	----------	22.94	--------	48.65	----------	39.10
Yield per acre	4.5 tons		9.0 tons	-----	7.0 tons	-----
Perharvest cost per ton of ensilage		5.10	--------	5.41	----------	5.59

1/ One pound of ladino at $2.20 per lb., 4 lbs. of timothy at $.113 per lb., and 3 lbs. of orchard grass at $.296 per lb., per acre. The total seeding cost of $3.54 divided by four, which is the usual number of years cut for hay.

2/ Average price of $4.75 per ton delivered to the farm and $5.90 delivered and spread on the fields.

Table 11.- Physical inputs and cost per acre for harvested silage corn by the field-chopper method. (Based on a 9-ton yield per acre and a field chopper used to chop about 300 tons annually) 1/

Item	Time required	Cost
	Hours	Dollars
Field chopper	1.0	10.90
Trailer canvas	2.0	.10
Motor and gear box for unloading	1.0	.70
Blower at silo	1.0	.60
Tractor	3.0	1.95
Man labor	5.0	3.25
Total per acre	-----	17.50
Estimated yield	9 tons per acre	
Estimated harvest cost per ton		1.94

1/ These estimates are based on a 5 man crew using three tractors, two trailers, a field chopper, and a blower. They cut about 1 acre per hour.

One man was on a tractor that pulled the chopper, one was on a tractor that pulled the trailers to the silo (wagons trailed behind the chopper), one staid at the blower to help in unloading, and one man staid in the silo to tramp the silage. A tractor was used to power the blower at the silo.

Table 12.- Estimated cost of harvesting silage corn with a tractor-drawn one-row binder and silo filler

Item	Use per acre	Cost per acre	Cost per ton of unsettled silage
	Hours	Dollars	Dollars
Cutting with one-row tractor-drawn binder:			
Row binder 1/	1.7	2.25	.25
Man labor	1.7	1.10	.12
Tractor	1.7	1.10	.12
Filling the silo:			
Silo filler 2/	1.3	.91	.10
Trailers or wagon	2.8	.06	.01
Tractor	3.9	2.53	.28
Man labor	9.0	5.85	.56
Twine	3.9 (lbs.)	.90	.10
Total	---	14.70	1.63

1/ Based on an annual cost of about $50 per year and used to harvest about 20 acres of corn or about 200 tons annually (table 4, page 11).

2/ Silo filler used about 65 hours per year with an estimated annual cost of about $45. A charge of $0.70 per hour was used.

The degree to which grass silage should replace corn silage varies greatly among farms within an area. Even in a hilly area with only fairly productive soils, some farms may have level bottom lands that will produce 12 to 15 tons or more of corn silage per acre. Comparisons of costs and incomes from alternative farm organizations (with and without grass silage) with consideration of the long-time influences on yields, must be made in order to get a satisfactory picture of the influence of grass silage. Within given limits the net income per farm may be about proportionate to the number of cows. Thus, if grass silage allows an increase in the number of cows kept total costs may be increased but net income is likely to be increased.

Through the influence of weather the quantity of grass silage produced may vary greatly within a few years. If the spring rainfall is less than normal and a light hay crop is in prospect, some farmers may increase the corn planted for silage. The influence of wet spring weather for several successive years (since 1944) has increased the amount of hay harvested for silage. In general, it seems probable that the amount of hay harvested for silage will increase, but the influence of weather cannot be minimized.

Some notes on feeding grass silage

This incidental information on feeding was collected from about 15 farms. Most of these farmers fed about 40 or 45 pounds of silage per day but the quantity ranged from 35 to 70 pounds. If grass silage was the only type of silage fed about the same number of pounds were fed as when corn silage was the only type in the ration. These 15 farmers usually fed equal amounts of silage in the morning and the evening. A few fed silage three times a day. Grain was usually fed in the morning and at night. Hay was usually fed at 10 or 11 o'clock in the morning and at night. Farmers reported that they fed from 6 to 20 pounds of hay per day; 10 to 18 pounds were most frequently reported. The number reporting this item was too small to establish a significant average.

Some farmers said that even if grass silage was fed in liberal quantities they still fed about the same amount of hay as when corn silage was used. Some said that when grass silage was fed their cows ate less hay than with corn silage. This subject needs further study as the farms that reported were too few for the results to be of much value.

Several farmers fed silage when pastures were short in the dry part of the summer. A few fed it even when the cows were on lush pastures; they reported that cows would usually eat some silage even then.

For most farms the interviewers learned only the amount of silage fed but on some farms they learned the amount of hay that was fed. The figures given in the examples below are in terms of ration per cow per day. Grain was fed in the morning and at night on all farms, but on only a couple of farms did the interviewers learn the quantity, as this part of the study was only incidental.

Farm no.

1. About 35 to 40 lbs. of alfafla silage were fed per day - equal parts at morning and at night. Data were not obtained on the amount of hay and grain fed.

2. 15 lbs. of alfalfa silage and 30 lbs. of corn silage were fed per day. An average of 10 to 11 lbs. of grain were fed per day. Hay was fed at noon and night, with an average of about 10 to 12 lbs. per cow per day.

3. About 42 lbs. of silage were fed per day - 20 lbs. of grass silage in the morning and 22 lbs. of corn silage at night. Hay was fed just before noon and at night, but the amount fed was not learned.

4. About 45 lbs. of silage were fed per day, of which about 25 lbs. were grass silage fed in the morning and 20 lbs. were corn silage fed at night. Hay was fed at 10 or 11 a.m. and at night. About 8 lbs. of grain and 17 lbs. of hay were fed per day.

5. 55 to 60 lbs. of grass silage were fed per day - equal parts at morning and at night. Mixed ladino and timothy hay was fed at 9 a.m. and again at 1:30 p.m. Alfalfa hay was fed at night. This farmer said he fed about 10 lbs. of hay per cow per day, but that they often did not

eat all of it when grass silage was also fed.

6. About 40 to 45 lbs. of grass silage were fed per day - equal parts at morning and at night. 12 lbs. of grain and 18 lbs. of hay were fed per cow per day.

7. 30 lbs. of silage were fed per day - equal parts at morning and at night. Hay was fed at 11 a.m. and night but the amount was not learned.

8. 70 lbs. of silage were fed per day, of which about 40 lbs. were grass and 30 lbs. corn silage. Data relative to hay feeding were not obtained.

9. Total silage ration averaged about 50 lbs. per day, of which about 55 percent was grass and 45 percent corn. Sometimes only one kind of silage was fed for a specified period. When this was the case, the ration was 55 lbs. of grass silage per day, and when corn silage was fed about 45 lbs. per day. Equal parts of silage were fed morning and night. Hay was fed at 10 or 11 a.m. and again at night. Cows consumed an average of about 10 lbs. of hay per day. About 10 lbs. of grain were fed per day.

10. 70 lbs. of silage were fed per day of which 15 lbs. were corn silage fed in the morning, 40 lbs were grass silage fed at noon, and 15 lbs. were corn silage fed at night. Hay was fed only at night and the ration was 6 lbs. per day.

11. A total of about 45 lbs. of silage were fed per day. Corn silage was fed in the fall until the supply was exhausted, then grass silage was used. This was done because the corn silage was stored in an old silo that was not airtight, and was subject to spoilage. Equal amounts of silage were fed at morning and at night. Hay was fed just before noon and at night - the amount was not learned. Grain was fed at the rate of about 1 lb. per 5 lbs. of milk produced.

12. A total of 55 to 60 lbs. of silage was fed per day of which about 65 percent was grass silage and 35 percent was corn silage. Equal parts of silage were fed at morning and at night. Hay was fed at about 11 a.m. only. This farmer said his cows consumed 10 or 12 lbs. of hay per day.

13. A total of 70 lbs. of silage was fed per day, of which about 45 lbs. were grass and 25 lbs. were corn silage. This farmer fed silage three times a day - grass in the morning, corn at noon, and grass at night. About 5 lbs. of hay were fed at night but he said the cows often did not eat all of it.

14. A total of 45 lbs. of silage was fed; of this 20 lbs were grass fed in the morning, and 25 lbs. were corn fed at night. Hay was fed just before noon and at night. The amounts of hay were not learned.

Suggested Reading List

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15. Estimating the quantity of Settled Corn Silage in a Silo, J. B. Shepherd and T. E. Woodward, U. S. Dept. of Agr. Cir. 603, April 1941.

16. Making and Feeding Legume Silage in Western Oregon, Oregon College of Agriculture, Bul. 669, Corvallis, Oregon.

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